OESI Power Corporation

July 8, 1991

Mr. Dean Nakano
State of Hawaii
Department of Land and Natural Resources
P.O. Box 621
Honolulu, Hawaii 96809

Subj: GEOTHERMAL WELL KS-8 UNCONTROLLED FLOW
EVENT REPORT DATED JUNE 24, 1991

Dear Mr. Nakano:

Enclosed please find the KS-8 Report of July 5, 1991 (identical to the report of June 24, 1991), which is confidential in nature as a whole report. However, per your request, the attached version is highlighting ("Red Line") all sensitive data which we consider strictly confidential and therefore cannot be released at all. I have confidence in your judgement as for the release of the rest of the document.

Please do not hesitate to contact me anytime should you have any questions or need further information.

Sincerely,

Maurice A. Richard
Regional Development Manager

Attachment

cc:
W. Paty, DLNR w/attachment

ZR/kk/ci

PUNA GEOTHERMAL VENTURE

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GEOTHERMAL WELL KS-8 UNCONTROLLED FLOW EVENT AND WELL DESIGN REVIEW

July 5, 1991

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GEOTHERMAL WELL KS-8 UNCONTROLLED FLOW EVENT AND WELL DESIGN REVIEW

1 INTRODUCTION

1.1 Background

Puna Geothermal Venture (PGV) is currently nearing completion of a 25 MW geothermal power plant located in the Puna District on the Big Island of Hawaii. PGV drilling activities commenced in November, 1990. The drilling activities completed to date include the completion of production well KS-3, the drilling of KS-7, and the rework of KS-1A (Figure 1). KS-7 was drilled as an injection well but was suspended prior to completion due to a high pressure zone which was encountered at the relatively shallow depth of 1678'. Geothermal well KS-8 was the third new well to be started by PGV as part of the well field development to supply steam to the PGV power plant.

KS-8 was originally planned as an injection well and was permitted under Underground Injection Permit (UIC) No. 1529 administered by the Hawaii Department of Health (HDOH). However, testing results from KS-3 and other power plant planning considerations led to the decision to drill KS-8 as a production well with the full production casing program. This well design is provided for in the UIC permit to construct. This change would allow the well to be used as a producer in the event that a significant production zone was encountered during drilling. A production well drilling permit for KS-8 was subsequently submitted to the Department of Land and Natural Resources (DLNR) which would allow for use of the well as a producer. That permit application is currently under review by DLNR

At 11:17 p.m. (Tecton recorded time) on Wednesday, June 12, during the drilling of KS-8, a high-temperature, high-pressure zone was encountered at a depth of 3488 feet. When this zone was penetrated, a powerful steam driven pressure pulse propagated rapidly up the well bore and impacted surface equipment, resulting in damage to parts of the blowout prevention equipment (BOPE) and the drill rig. The well continued to produce a strong flow of geothermal steam, brine, and gas through the damaged blowout prevention equipment. The flow continued for approximately 31 hours before control of the well was restored.

1.2 Purpose

The purpose of this document is as follows:

* To describe in detail the drilling activities immediately prior to, during, and after the uncontrolled flow event.

* To describe the reservoir conditions that caused the event.

* To describe the mode of equipment failure that allowed uncontrolled release of steam from the well.

* To describe the operations that were taken and that will continue to be taken to achieve satisfactory control and completion of the well.

* To describe the proposed drilling equipment and procedures modifications to be implemented in order to prevent recurrence of the event.

1.3 Scope

This document pertains to the KS-8 drilling activities immediately prior to, during, and after the uncontrolled flow event of June 12, 13, and 14, 1991 and to ongoing and proposed drilling activities required to successfully control and complete KS-8.

1.4 Nomenclature

Several key terms will be used repeatedly throughout this document. These terms are defined as follows:

THE KICK	The sudden high pressure impact or impacts that caused the damage to the BOP equipment and drill rig.
THE EVENT	The occurrences spanning the time beginning with the kick and ending when well control was established.
WELL CONTROL	The stoppage of steam flow from the well and partial control of wellhead pressure by means of water injection.
KILL	Complete control of well pressure by means of heavy mud or cement.

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2 DRILLING ACTIVITIES PRIOR TO, DURING, AND AFTER THE UNCONTROLLED FLOW EVENT

2.1 Drilling Program

See Attachment A: Drilling Program, Production\Injection Well KS-8.

2.2 Well and Rig Configuration at the Time of the Event

The current well configuration is shown in Figure 3. The rig configuration is shown in Attachment A. The water supply to the rig consists of the PGV water well capable of supplying 400 gpm of water at 104 deg.F. A 500,000 water tank filled from the water well is connected to the drill pad via a 4" PVC pipe with gravity feed. An auxiliary water supply of approximately 100 gpm is available from a hookup to municipal water main at Pad E.

2.3 KS-8 Drilling History

5/1/91

Moved in and rigged up with Parker Drilling Co., rig #231, on well KS-8. Picked up Eastman mud motor and drilled rat hole. Rig on day rate 0300 hrs. 5/2/91.

5/2/91

Drilled rat hole with mud-motor using 12 1/4 inch bit. Picked up 26 inch bit with mud-motor. Drilled 26 inch hole from 35 ft. to 77 ft. Laid out bottom hole assembly, picked up 42 inch hole opener. Waited on daylight because of noise complaints.

5/3/91 Depth 77 ft.

Wait on daylight because of noise complaints. Opened 26 inch hole to 42 inches.

5/4/91 Depth 74 ft.

Opened 26 inch hole to 42 inch hole to 74 ft. Laid down bottom hole assembly. Picked up 30 inch conductor and run in hole, set pipe on bottom. Pick up 1 joint of 5 inch drill pipe, blew hole dry with air and foam, laid out drill pipe. Cemented 30 inch conductor with 35 sxs. Hawaii cement. Waited on cement. Cemented top of 30 inch conductor with 9 cubic yards of ready mix cement.

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Topped off cement job on conductor with 115 sxs. Hawaii cement. Welded on rotating head to 30 inch conductor and continued to nipple up.

5/5/91 Depth 74 ft.

Continued nippling up rotating head. Picked up 26 inch drilling assembly ran inside 30 inch conductor. Drilled cement inside conductor. Drilled formation from 74 ft. to 109 ft. with 26 inch bit. Serviced rig. Drilled 26 inch hole 109 ft. to 162 ft. Pulled out of hole, laid out mud motor because of noise, ran in hole with conventional assembly and drilled 26 inch hole from 162 ft. to 174 ft.

5/6/91 Depth 269 ft.

Continued to drill 26 inch hole, serviced rig, drilled 26 inch hole to 269 ft.

5/7/91 Depth 481 ft.

Drilled 26 inch hole, serviced rig, drilled 26 inch hole, tripped out of hole, picked up jars and changed out rotating head.
Drilled 26 inch hole to 481 ft.

5/8/91 Depth 587 ft.

Drilled 26 inch hole, serviced rig, drilled 26 inch hole to 587 ft.

5/9/91 Depth 655 ft.

Drilled 26 inch hole to 630 ft., circulated hole at 630 ft. Pulled out of hole, rigged up bailing assembly. Bailed water with external sand line at 630 ft. Bailed water until acceptable sample
was obtained for state authorities. Rigged down swabbing unit. Changed out bottom hole assembly, ran in hole with new assembly, washed and reamed from 605 ft. to 630 ft. Circulated at 630 ft., drilled 26 inch hole to 655 ft.

5/10/91 Depth 771 ft.

Drilled 26 inch hole, serviced rig, drilled 26 inch hole to 771 ft.

5/11/91 Depth 1026 ft.

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Drilled 26 inch hole, serviced rig, drilled 26 inch hole, worked tight hole at 1011 ft. Drilled 26 inch hole to 1026 ft.

5/12/91 Depth 1039 ft.

Drilled 26 inch hole, circulated and conditioned hole at 1026 ft. Pulled out of hole, picked up 26 inch reamers. Ran in hole with new assembly to 169 ft., reamed 26 inch hole from 169 ft, to 347 ft. Pulled out of hole, waited because of noise complaints, ran in hole, reamed from 347 ft. to 376 ft.

5/13/91 Depth 1039 ft.

Reamed 26 inch hole from 347 ft. to 940 ft. without mud returns.

5/14/91 Depth 1049 ft.

Reamed 26 inch hole from 940 ft. to 1039 ft., drilled 26 inch hole from 1039 ft. to 1049 ft. Circulated and conditioned hole. Made short trip to collars, ran in hole, found 23 ft. of fill on bottom. Reamed 26 inch hole 1026 ft. to 1049 ft. Circulated and conditioned hole. Pulled out of hole with drilling assembly. Rigged up casing crew to run 20 inch casing, ran 20 inch casing.

CASING DETAIL

2.75 FT. Halco 20 inch shoe
1029.27 FT. 26 jts. 20 inch 94# K-55 Buttress casing
1032.02 FT. Total

Washed 20 inch casing to bottom last 4 feet. Rigged down casing crew.

5/15/91 Depth 1049 ft.

Finished rigging down casing crew. Picked up stab-in sub for 30 inch shoe, ran in hole with sub on 5 inch drill pipe. Stung into 30 inch float shoe, filled DP*20 inch annulus with water. Cemented 20 inch casing, pumped 20 bbls. water, followed by 20 bbls. Super Flush, followed by 1 bbl. water. Cemented through 5 inch drill pipe with 445 sxs. Hawaii cement, 50#/sx. Spherelite, 40 % Silica Flour, 4 % gel, 1.25 % CFR-3. yield 3.4 cubic ft/ sx., weight 11#/gal. Tailed with 154 sxs. Hawaii cement, 40 % Silica Flour, .65 % CFR-3, 3 % CaCl-2. yield 1.64 cubic ft./sx, weight 15.4 #/gal. Displaced cement down drill pipe with 10 bbls. water. Pulled out of hole with drill pipe, waited on cement.

Ran in hole with 1 inch pipe down 26*20 inch annulus to 767 ft. Cemented through 1

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inch pipe with 138 sxs. Hawaii cement, 40 % Silica Flour, .65 %CFR-3, 3 % CaCl-2. Pulled out of hole with 1 inch pipe, waited on cement, ran in hole with 1 inch pipe.

5/16/91 Depth 1049 ft.

Continued to run 1 inch to 767 ft. Cemented through 1 inch pipe with 170 sxs. Hawaii cement, 40 % SSA-1, .65 % CFR-3, 3 % CaCL-2. Pulled out of hole, waited on cement. Ran in hole with 1 inch pipe to 767 ft., cemented with 159 sxs. Hawaii cement, 2-1 Perlite, 40 % Silica Flour, 4 % gel, 3 % CaCl-2. yield 3.4 cubic ft./sx, weight 11 #/gal. Waited on cement, ran in hole with 1 inch pipe to 767 ft., cemented through 1 inch pipe with 308 sxs. Hawaii cement 40 %SSA-1, 2-1 Perlite, 4 % gel, 3 % CaCl-2, waited on cement.

5/17/91 Depth 1049 ft.

Waited on cement, ran in with 1 inch pipe to top of cement at 780 ft. Cemented through 1 inch pipe with 500 sxs. Hawaii cement, 40 % Silica Flour, 4 % gel, 3 % CaCl-2. Pulled out of hole with 1 inch pipe, waited on cement. Ran in hole with 1 inch pipe to top of cement at 300 ft. Cemented through 1 inch pipe with 500 sxs. Hawaii cement, yield 1.15 cubic ft/ sx, weight 15.8 #/gal. Pulled out of hole, waited on cement, ran in hole with 1 inch pipe to top of cement at 270 ft, cemented through 1 inch pipe with 500 sxs Hawaii cement, cement to surface. Waited on cement. Cut-off 20 inch casing, laid out same with 30 inch conductor. Nippled up Hydril and rotating head.

5/18/91 Depth 1049 ft.

Continued nippling up Hydril and rotating head. Laid down 26 inch bottom hole assembly. Picked up 17 1/2 inch bottom hole assembly, ran in hole with new assembly. Worked on cemented up Hydril, continued running in hole. Tested casing, pumped into formation at 400 psi. Cut and slipped drilling line, pulled out of hole.

5/19/91 Depth 1049 ft.

Finished pulling out of hole, changed out 1 jt. drill pipe, ran in hole with 5 inch drill pipe to top of cement at 996.48 ft. Serviced rig, Rigged up Halliburton, cemented inside 20 inch casing with 120 sxs. neat cement. Closed Hydril with 15 bbls out drill pipe, squeezed cement, cement locked up at 20 inch shoe. Bled off pressure, pulled out of hole. Ran in hole with bottom hole assembly, drilled out cement and shoe, circulated bottoms up, pulled out of hole. Stood back bottom hole assembly, ran in hole open ended to T.D., circulated bottoms up. Rigged up Halliburton cemented through drill pipe with 380 sxs. Hawaii cement, pulled 3 stands, attempted to fill hole, not successful. Pulled out of ole, waited on cement.

5/20/91 Depth 1100 ft.

Waited on cement, ran in hole with 17 1/2 inch bit on bottom hole assembly to top of cement at 844 ft. Drilled cement from 844
to 1028 ft. Tested casing to 600 psi. Repaired leak in flange leading to kill line. Pressure tested Hydril to 600 psi. for 30 minutes. Hydril tested O.K. Drilled cement with 17 1/2 inch bit from 1028 ft. to 1049 ft. Tested formation pressure, leak off test. Pumped into formation at 400 psi. while pumping with rig pump at 94-100 strokes. Installed rotating head, drilled 17 1/2 inch hole from 1049 ft. to 1100 ft., circulated on bottom.

5/21/91 Depth 1100

Took directional survey at 1060 ft. (2 1/4 degrees). Pulled out of hole, ran in hole open ended, Kelly ended up above rotary table, washed 19 ft. of fill. Rigged up Halliburton, cemented through drill pipe with 129 sxs. Hawaii cement, 8 % gel, 3 % CaCl-2. Pulled out of hole, serviced rig. Ran in hole with drilling assembly to top of cement at 1008 ft. Drilled cement from 1008 ft. to 1055 ft. Swept hole, circulated, pulled out of hole, ran in hole open ended, circulated. Rigged up Halliburton, cemented through drill pipe with 105 sxs Hawaii cement with 8 % gel, pulled 2 stands, closed Hydril, squeezed cement with water, pumped 36 bbls. into formation to 500 psi squeeze pressure. Pulled out of hole, waited on cement.

5/22/91 Depth 1100 ft.

Ran in hole with 17 1/2 inch bit, drilled cement from 1031 ft. to 1057 ft. Pressure tested, pressure went from 180 psi. to 130 psi. before shut down. Cleaned mud tank, serviced rig, pulled out of hole, ran in open ended, dropped stand of drill pipe in hole, picked up fishing tools, ran in hole, engaged fish, pulled out and laid down fish. Ran in hole open ended to 1023 ft., with Kelly up, circulated hole. Rigged up Halliburton, cemented through open ended drill pipe with 243 sxs. Hawaii cement, 8 % gel, yield 1.89 cubic ft/ sx, weight 13.2 #/gal. Pulled 3 stands closed Hydril, squeezed with 35 bbls. water to 800 psi., locked up, shut in for 30 minutes with 800 psi. Pulled out of hole, waited on cement.

5/23/91 Depth 1150 ft.

Ran in hole to top of cement at 812 ft., drilled cement from 812 ft. to 1050 ft. Pressure tested formation to 100 psi., pressure did not hold, fell to zero psi. Drilled cement from 1050 ft. to 1100 ft., circulated made mud sweep. Pulled out of hole, ran in hole open ended to 1150 ft., circulated, rigged up Halliburton, cemented through drill pipe with 200 sxs. Hawaii cement,1-1 Perlite, 3 % gel, .75 % CFR-3, 3 % CaCl-2, 40 % Silica Flour. Displaced cement with water, waited on cement.

5/24/91 Depth 1386

Continued waiting on cement, ran in hole to top of cement at 940 ft. Drilled cement from 940 ft. to 1150 ft. Drilled formation with 17 1/2 inch bit from 1150 ft. to 1165 ft. Pulled up to casing shoe, cleaned mud pits washed and reamed from 1121 ft. to 1165 ft., drilled, surveyed, drilled 17 1/2 inch hole to 1386 ft.

5/25/91 Depth 1406 ft.

Pulled out of hole with bottom hole assembly. Ran in hole open ended, circulated, rigged up Halliburton, cemented through drill pipe with 205 sxs Hawaii cement, 40 % Silica Flour, 8 % gel. Pulled out of hole, waited on cement, ran in hole to top of cement at 1198 ft. Drilled cement from 1198 ft. to 1386 ft. Pulled out of hole with plugged bit, ran in hole, picked up Kelly and circulated at bottom.

5/26/91 Depth 1549 ft.

Drilled 17 1/2 inch hole from 1386 ft. to 1549 ft., circulated and conditioned hole, pulled out of hole, ran in hole open ended to cement. Circulated, rigged up Halliburton, cemented through drill pipe with 220 sxs. Hawaii cement, 2 % CaCl-2. Pulled out of hole, picked up bottom hole assembly, ran in hole to bottom of 20 inch casing, waited on cement. Ran in hole to top of cement at 1367 ft. Drilled cement from 1367 ft. to 1549 ft. Pulled out of hole with plugged bit.

5/27/91 Depth 1828 ft.

Continued pulling out of hole with plugged bit, ran in hole to bottom of casing, cleaned mud tanks. Filled pits with mud, ran in hole, tagged fill at 1412 ft. Washed and reamed from 1412 ft. to 1549 ft, drilled 17 1/2 inch hole. Surveyed at 1550 ft. (S 85 W) Continued drilling 17 1/2 inch hole to 1828 ft.

5/28/91 Depth 2020 ft.

Drilled 17 1/2 inch hole, circulated, surveyed at 1820 ft. (1.75 degrees, S 80 W). Final closure, S 44.79 W, final closure distance 31.990 ft. Drilled, serviced rig, drilled. Pulled out of hole, ran in hole open ended, found 5 ft. of fill on bottom, circulated at bottom. Rigged up Halliburton and cemented through drill pipe with 290 sxs. Hawaii cement, 2 % CaCl-2. Pulled out of hole, picked up bottom hole assembly, tripped in hole to 20 inch casing shoe. Waited on cement, continued to run in hole.

5/29/91 Depth 2134 ft.

Ran in hole to top of cement at 1848 ft., drilled cement from 1848 ft. to 2020 ft. Drilled 17 1/2 inch hole, serviced rig, drilled 17 1/2 inch hole to 2134 ft. Circulated and conditioned hole to run 13 3/8 inch casing. Made short trip to shoe, no fill on bottom, circulated, pulled out of hole. Rigged up casing crew to run 13 3/8 inch casing.

5/30/91 Depth 2134 ft.

Ran 13 3/8 inch casing.

CASING DETAIL:

1.10 ft.	Halco shoe
32.25 ft.	1 jt. 13 3/8, 61#, K-55, New Vam csg.
2.75 ft.	Halco float collar
1872.98 ft.	50 jts. 13 3/8, 61#, K-55, New Vam csg.
219.66 ft.	6 jts. 13 3/8, 68#, L-80, New Vam csg.
2128.74 ft.	TOTAL

Rigged down casing crew. Ran in hole with 5 inch drill pipe with screw in sub, screwed into float shoe inside 13 3/8 inch casing. Circulated hole, rigged up Halliburton to cement. Cemented 13 3/8 inch casing with 705 sxs. Hawaii cement, 50#/sx Spherelite, 40 % SSA-1, 1.25 % CFR-3, yield 3.40 cubic ft./sx weight 11.2 #/gal., 2400 cubic ft. total, followed by 154 sxs. Hawaii cement, 40 % SAA-1, .65 % CFR-3, yield 1.62 cubic ft. /sx, weight 15.5 #/gal., total 250 cubic ft.

Displaced down drill pipe, had good cement returns to surface, rigged down Halliburton, pulled out of hole, waited on cement. Cement fell 174 ft. in casing annulus. Cemented in annulus through 1 inch pipe with 100 sxs. Hawaii cement, 40 % SAA-1, .65 %CFR-3, yield 1.62 cubic ft./sx., weight 15.5 #/gal. Waited on cement.

5/31/91 Depth 2134 ft.

Continued to wait on cement. Made final cut on 13 3/8 inch casing, nippled down 20 inch head and casing. Welded on 13 3/8 inch 3000 # well head, preheated with Hot-head.

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6/1/91 2153 ft.

Nippled up 13 5/8 inch BOP stack, welded on flow line. Function tested rams and Hydril HCR valve. Tested blind rams to 600 psi. for 30 minutes O.K. Changed out bottom hole assembly, ran in hole to top of cement at 2073 ft. Pressure tested casing to 600 psi., O.K. Tested pipe rams, choke manifold, Hydril to 600 psi for 30 minutes, O.K. Drilled float collar, tested float to 600 psi. for 30 minutes O.K. Drilled 12 1/4 inch hole from 2134 ft. to 2153 ft.

6/2/91 Depth 2335 ft.

Cleaned pits, washed and reamed to bottom, 18 ft. of fill on bottom. Drilled 12 1/4 inch hole from 2153 ft. to 2276 ft. Circulated bottoms up, took survey at 2225 ft. (3 1/4 degrees S89 W). Pulled out of hole, laid down bottom hole assembly. Picked up mud motor, 1 1/2 deg. bent sub and ran in hole, circulated. Attempted to orient mud motor, could not engage mule shoe, pulled out of hole and worked on bent sub. Ran in hole, circulated and oriented mud motor at 2266 ft. Drilled 12 1/4 inch hole from 2136 ft. to 2347 ft.

6/3/91 Depth 2627 ft.

Blew out Kelly hose, pulled drill string to 13 3/8 inch casing shoe. Replaced Kelly hose, ran in hole, surveyed at 2297 ft. (2 1/2 deg. N69W), drilled 12 1/4 inch hole from 2347 ft. to 2410 ft. Surveyed at 2360 ft. (2 deg. N 8 W). Drilled from 2410 ft. to 2598 ft., surveyed at 2484 ft. (2 3/4 deg. N85E), circulated, pulled out of hole SURVEYS:

2423 ft. 1 1/4 deg. N26E
2454 ft. 1 3/4 deg. N75E
2484 ft. N85E

6/4/91 Depth 2820 ft.

Picked up bottom hole assembly, ran in hole, washed and reamed from 2270 ft. to 2627 ft. Drilled 12 1/4 inch hole from 2627 ft. to 2641 ft., surveyed, pulled out of hole. Laid down bottom hole assembly, picked up mud motor, ran in hole, oriented tool, drilled and surveyed to 2820 ft.

SURVEYS:
2614 ft. 6 1/4 deg. S68E
2639 ft. 6 1/4 deg. S61E
2730 ft. 6 deg. S45E
2757 ft. 6 deg. S39E

Final closure direction S 29.77 E; final closure distance 38.708 ft.

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6/5/91 Depth 2993 ft.

Drilled 12 1/4 inch hole with mud motor, surveyed, pulled out of hole, laid out mud motor. Picked up bottom hole assembly, ran in hole to shoe, cut drilling line, ran in hole, washed and reamed from 2627 ft. to 2936 ft. Drilled, surveyed, drilled to 2993 ft.

SURVEYS:
2824 ft. 7 3/4 deg. S40E
2855 ft. 8 1/4 deg. S38E
2951 ft. 8 1/2 deg. S36E

Closure direction S 3.15 W, closure distance 54.385 ft.

6/6/91 Depth 3318 ft.

Drilled 12 1/4 inch hole, surveyed, pulled out of hole, changed out bottom hole assembly, ran in hole. Washed and reamed from 3032 ft. to 3075 ft., drilled, surveyed, drilled to 3318 ft.

SURVEYS:
3045 ft. 8 deg. S40E
3142 ft. 7 1/2 deg. S42E
3207 ft. 8 deg. S41E
3300 ft. 8 3/4 deg. S42E

Closure direction S 17.30 E, closure distance 95.9 ft.

6/7/91 Depth 3401 ft.

Drilled 12 1/4 inch hole, surveyed, drilled, circulated for trip, pulled out of hole. Picked up mud motor, bent sub, and ran in hole. Made rig repairs, ran in hole, circulated, took survey. Attempted to drill, mud motor inoperable. Pulled out of hole 15 stands, well started to flow, ran back to bottom. Circulated and built mud weight.

6/8/91 Depth 3401 ft

Well depth 3401, circulated and built mud weight from 9 #/gal to 10.5 #/gal in 1/10 #/gal increments. Spotted 11.2 #/gal mud pill on bottom. Pulled out of hole with mud motor and angle building assembly, well flowed 1 inch stream continuously. Ran in hole open ended with 5 inch drill pipe, circulated bottoms up at 13 3/8 inch casing shoe. Ran in hole to bottom, circulated bottoms up.

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Cemented at 3401 in 12 1/4 inch hole through drill pipe with 50 sxs Hawaii cement, 20 % AA1, .75% CFR-3, and Halad-22. Displaced cement with 59 bbls. drilling mud. Pulled 3 stands and circulated, well continued to flow. Waited on cement, ran in hole and tagged cement at 3289 ft. Cemented through open ended drill pipe with 28 sxs Hawaii cement, 20 % AA-1, .75% CFR-3, .05% Halad-22A, displaced cement with 58 bbls of drilling mud. Pulled out of hole with drill pipe. Picked up drilling assembly and ran in hole to top of cement at 3151 ft. Drilled cement in 12 1/4 inch hole from 3151 ft. to 3350 ft. Circulated to cool hole, conditioned mud.

6/10/91

Checked well for flow, well still flowing 1 inch stream to mud pits. Pulled out of hole and ran in hole open ended to 2135 ft., circulated, ran in hole to 3350 ft., circulated bottoms up. Spotted cement plug; cemented through drill pipe with 50 sxs Hawaii cement, 40% SAA1, .75% CFR-3, .3% Halad 22, displaced cement with 58 bbls. of drilling mud. Pulled up to 2135 ft., circulated and waited on cement. Ran in hole and tagged top of cement at 3140 ft. Circulated, pumped cement through drill pipe at 3120 ft; cemented with 35 sxs Hawaii cement, 40% SAA1, .75% CFR-3, .3% Halad-22, displaced cement with 54 bbls. drilling mud. Pulled 5 stands and squeezed cement at 2660 ft. Closed in well, squeezed away 3 bbls, at 300 psi. Pulled out of hole, picked up drilling assembly and ran in hole to 13 3/8 inch casing shoe, circulated.

6/11/91

Finished trip in hole, tagged top of cement at 2845 ft. Drilled cement in 12 1/4 hole from 2845 ft. to 3350 ft., circulated and conditioned mud in hole for log, pulled out of hole 8 stands, gained 20 bbls mud in pits, ran in hole to bottom, circulated and cooled hole. Checked for flow, 1 inch flow to pits, pulled out of hole, rigged up HLS logging services to run temperature log.

NOTE: The reasons for running the temperature logs at this depth were to develop diagnostics in an attempt to determine a correlation of temperatures in well KS-8 as compared to the temperatures encountered and logged in well KS-3.

Two HLS logging services logging runs were run, temperatures were continually displayed in the HLS logging truck and recorded on both magnetic tape and a standard paper temperature log. Well KS-8 was logged to a depth of 3325 ft., the top of cement at this time was at 3350 ft. The logging tool was not allowed to run into the bottom of the hole in order to avoid becoming stuck in the cement

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at 3350 ft. The first temperature logging run encountered a maximum temperature of 370 degrees F. at a depth of 3325 ft. The temperature data was plotted on a graph of depth vs. temperature, on the same graph a temperature graph of well KS-3 was also plotted to obtain correlation between KS-8 and KS-3. (Graphs are part of this report).

A temperature correlation was obtained between KS-3 and KS-8 and it was determined from the correlation that based on temperature well KS-8 encountered temperatures equivalent to well KS-3 but at a depth of approximately 550 ft. deeper in well KS-8; ie, the temperature of 370 degrees F. encountered in well KS-8 was encountered at a depth of 3400 ft. whereas the temperature of 370 degrees F. was encountered in well KS-3 at a depth of 2850 ft. At the conclusion of HLS temperature log run # 1 while pulling out of the hole and attempting to log up the hole the HLS tool failed, most likely because of excess temperature. (HLS wire-line was rated to a max temperature of 500 degrees F.)

It was decided by PGV personnel to run an additional temperature log in well KS-8 in order to gain some idea of the rate of temperature buildup in the well. Another temperature tool was selected and HLS rigged up to run an additional temperature survey. In addition to the temperature tool it was decided to run two MRT's on top of the logging tool. MRT (maximum recording temperature). The HLS temperature tool was run in the well and temperature recording was commenced at a depth of 2204 ft, the shoe depth of the 13 3/8 inch casing. The HLS tool logged down to a depth of 3325 ft. where the tool failed due to excess temperature above what the tool and logging wireline were rated for. The HLS tool was brought out of the hole and the two MRT's were examined to determine the maximum temperature to which they were exposed. The top MRT was broken and no data were obtainable. The bottom MRT failed to register a maximum temperature.

Afternoon of 6/12/91

A meeting was called in the offices of PGV, attendees were as per recall:
Bill Teplow
Jeff Sternfield
Bill Livesay
Butch Clark
Terry Crowson
Wendell Howard

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It was decided at the meeting referred to above that PGV would elect to drill deeper in order to set the 9 5/8 inch casing in the well at a depth nearer to 4000 ft. as originally detailed in the well prognosis. It was decided to drill out the cement in the bottom of the well after circulating bottoms up at 3350 ft. It was decided to maintain a mud weight of 10.5 #/gal in circulating bottoms up and to drill ahead with this mud weight. It was also decided to make MRT runs inside the drill pipe at every stand after drilling recommended. It was planned to plot the MRT data on the temperature graphs and by means of this data to ascertain when to run 9 5/8 inch casing.

RETURN TO DAILY DRILLING REPORTS

6/12/91

Ran HLS logs, DLS, GR, GRD, Temperature, logged down to 3325 ft. started to log up HLS tool failed while coming up hole. Re-rigged HLS and ran temperature tool only, tool was run in to 2204 ft. and logging commenced from that depth on down, HLS tool failed at or near well depth of 3325 ft. Pulled out of hole with HLS tool and rigged down lubricator. Picked up bottom hole assembly and ran in hole to top of cement at 3350 ft. Drilled out cement in 12 1/4 inch hole from 3350 ft. to 3401 ft. Drilled out of cement and drilled new formation from 3401 ft. to 3476 ft. Well unloaded, indications to the driller were that pump pressure was increasing and the driller was picking up the Kelly to close the BOP's when the well unloaded.

6/13/91

Attempts were made to kill Well KS-8. (Details are listed in Section 2.5 Well Control Activities)

SUMMARY OF WELL CONTROL PROCEDURE:

Picked up on kelly, closed bottom pipe rams,(steel rams). Rams even though closed , leaked steam and water, closed in on top rams and opened on 4 inch kill line. Rigged up on standpipe and closed standpipe valve, pumped water through standpipe and kelly hose with Halliburton, pumped down drill pipe at 9 bbls/minute. Opened up choke line to divert flow from under the rig. Closed choke line pumping 9 bbls/min down drill pipe at 1400 psi. Worked on getting in to bottom of cellar to hook up to 13 3/8 inch casing head valves in order to dead head water into well.

6/14/91

Continued to attempt to kill well, worked in cellar, hooked up to 13 3/8 inch wing valves on casing head. Rigged Halliburton to wing valves, pumped down 13 3/8 inch annulus at 5 bbls/minute with water at 1700 psi, pressure gradually decreased to 1000 psi., concurrently with pumping into annulus pumped down drill pipe with water at 5 bbls/ minute at 900 psi.

6/15/91

Pumped lost circulation material into 13 3/8 inch wing valves in an attempt to seal off around pipe rams and to stop leakage of steam and water around stack. Lost circulation material succeeded in plugging off leaks around pipe rams. Hydrogen sulfide emissions ended at this time (7:00 am). Cleared off rig floor, worked toward rig repair. Continued to pump down drill pipe and into casing annulus.

Drill pipe	4 bbls/min	900 psi.
Casing	4 bbls/min	950 psi.

6/16/91

Worked on Parker Drilling Co. mud lines, Changed out top drill pipe rams in BOP stack. Closed top rams on drill pipe, opened bottom set of rams, stack held O.K.. Changed over from pumping with Halliburton to pumping with Parker Drilling Co. rig pumps. Released Haliburton, changed out Hydril rubber. Continued pumping into well.

Drill pipe	4 bbls/min	900 psi.
Casing annulus	4 bbls/min	950 psi.

6/17/91

Pumped into well with cold water:

Drill pipe 3.5 bbls/min., 678 psi.

Casing 4.5 bbls/min., 827 psi.

Continued with rig repair, replaced floor plates, flow lines, air lines, electric lines, etc.

6/18/91

Continued with rig repairs, continued pumping water into well.

Drill pipe 3.0 bbls/min, 650 psi.

Casing 3.0 bbls/min, 900 psi.

Attempted to change out TIW valve on bottom of Kelly, well flowed back with full 2 inch stream. Shut pipe in and pressure increased to 700 psi. Continued to pump cold water into well.

6/19/91

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Continued to pump water down drill pipe and into well annulus to cool well. Rigged up Halliburton and Parker Drilling Co. pumps to well annulus, performed an injection test into the annulus. Pumped 17.5 bbls/min. at 1000 psi, limit of pumping capability. Rigged up to drill pipe and annulus and continued to pump cold water into well. Mixed and pumped 40 bbl. LCM pills into well annulus at intervals in an attempt to plug off upper thief zone in well.

6/20/91

Continued to pump cold water into well. Pumped 100 bbl. pills with 20-25 % LCM, 45-50 viscosity into well annulus, did not observe change in well behavior. Continued to work on rig repairs, installed additional cooling tower, installed flow nipple and flow line.

2.4 Uncontrolled Flow Event

The probable cause of failure was insufficient flow capacity to relieve pressure kick. The insufficient relief flow area caused the annular preventer element to fail. The failed preventer element choked the flow path of the spacer between the Hydril and the rotating head. This resulted in a second rupture that damaged the mud line and the flow line. This also caused the rig floor to be displaced. This prevented the driller from staying on the brake resulting in kelly dropping down. The position of the kelly interfered in the complete closure of the upper pipe ram. The leakage around the upper pipe ram totally engulfed the rig floor in steam.

The complete lack of visibility on the rig floor and the displacement of the floor plates and other parts of the rig necessitated waiting until daylight before proceeding.

The rupture of the rotating head spacer spool damaged the mud line, flow line and pneumatic control lines under the rig floor.

The following is the sequence of events and actions taken during the kick and uncontrolled flow:

1. Portions of the blow out preventer stack were damaged at the time that the steam or CO_2 blew out above the Hydril.

2. The Hydril annular preventer was damaged by the excessive pressure impulse of the gas. The Hydril was inoperative.

3. The driller was forced away from the brake and the kelly dropped into the area of the pipe ram closure. Pipe rams will not close completely around the hexagonal kelly, therefore there was leakage around the kelly which prevented

working on the floor. The rig floor was engulfed in steam.

4. The location was cleared and all personnel were accounted for.

5. Agencies and PGV personnel were notified.

6. The following decisions were made:

   a. Shut down electric power to the rig drawworks at the SCR panel.

   b. Safety trailer was to be moved from the site to a location above the site and away from the well head.

   c. It was also decided to wait till daylight to reassess the situation and to take other actions around the rig and on the rig floor.

7. Personnel with safety gear moved the safety trailer from the site to a location above the site and away from the well head.

6/13/91 6:00 AM

8. At dawn the HCR valve was opened venting the well through the choke manifold and the leakage around the kelly in the pipe rams.

9. It was at this point that it became known that

   a. The Hydril was inoperative

   b. The damage to the kill line and to the mud line had caused the pumps to pump onto the drill site and not down the drill pipe. The mud pits were dry.

   c. The bottom metal to metal pipe rams and the blind rams were still open.

10. It was decided to mobilize Halliburton to pump cold water down the drill pipe.

11. Parker crews rigged the Halliburton cementing lines to the standpipe and closed the lower valve. This established the path to pump fluids down the drill pipe.

12. Halliburton was rigged to pump down the drill pipe through cementing lines.

(6/13/91 10:30 AM)

13. Closed in the choke line. Pumping 9.5 bbls/min. Pressure 1700 psi decreasing to 900 psi.

14. Rigged up lines to Halliburton to pump down the annulus. Pump 5 bbls/min down the annulus. Initial pressure 1700 psi reducing to 1000 psi. Pumping down the drill pipe 4 bbls/min pressure still 900 psi. (6/14/91 4:00 AM)

15. Pumped LCM to plug off steel pipe rams. Flow was controlled. (6/14/91 10:00 AM)

16. Change out the top pipe rams. Steel rams with LCM held.

6/16/91 12:00 NOON

17. Open steel pipe rams. Top pipe rams are closed. The choke line is closed. Continued to pump down the drill pipe and annulus.

18. Clean and reconstruct rig floor.

19. Repair Hydril. (6/17/91 2:00 AM)

20. Repair rig and mud system.

21. Current (6/24/91) well configuration is shown in Figure 3.

2.5 Well Control Activities

The following approach is designed to cut off the cross flow between the zone at 3450' and the fracture at the shoe at 2100'.

MATERIALS TO BE USED IN THIS PROCEDURE

2000 bbls of 22 ppg Mg Al hydroxide / Iron oxide mud
2000 bbls of 10 ppg Saturated salt water
Lost circulation material to shut off shoe fracture.

TANK STORAGE CAPACITY

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The combined storage volume is as follows:

Parker Drilling 231	650 bbl
True Drilling 051	1000 bbl
4 Baker tanks (475 bbl)	1900 bbl
Capacity of 10" line	126 bbl
	3676 bbl
Additional storage tank on order from PDC	500 bbl
Total	4176 bbl

PUMPING CAPACITY

The estimated pumping capacity of the Parker 231, the Halliburton trucks and the True 051 is 54 bpm.

Parker Drilling 231	12 bpm
True Drilling 051	24 bpm
Halliburton	18 bpm
	54 bpm
Additional pumping capacity on order	12 bpm
Total	64 bpm

MANIFOLDING

The pumps will be manifolded together for the total flow rate. Cannot move the True pumps; therefore we will need pipeline from KS-11 to KS-8. Use existing well test 10" line to separator on KS-3. Pipe True flowrate over to the KS-3 site.

Flow rate - pressure drop relationships will be calculated and tested.

A Halliburton cementing head or frac head will be used on the drill pipe manifolding. Manifolding for Halliburton and True 051 to the annulus will be fabricated and tested.

The following things can be started immediately:

a. Pipe from True rig to pipeline at KS-3 and from pipeline at KS-8 end to manifold on annulus.

b. Relocate Baker tanks

c. Manifold Baker tanks

d. Change out Hydril element

SNUBBING UNIT

In addition to the extra tanks and additional pumping capacity Cudd Pressure Service is being mobilized to Hawaii for use in snubbing drill pipe and BHA out of the hole and back in should this be necessary.

PROCEDURES

1. Rig and test manifolds for fluid transfer and pumping down the drill pipe and casing. Place tanks and other equipment as needed. Strip out 2 joints of drill pipe. (Question of opening float valve and enlarging nozzle flow area versus snubbing out and in will be determined based on temperature information.)

2. Establish pumping rates and schedule for 22 ppg kill fluid, 10 ppg fluid, lost circulation materials and cement.

3. Mix and store the fluids as established in Step 2.

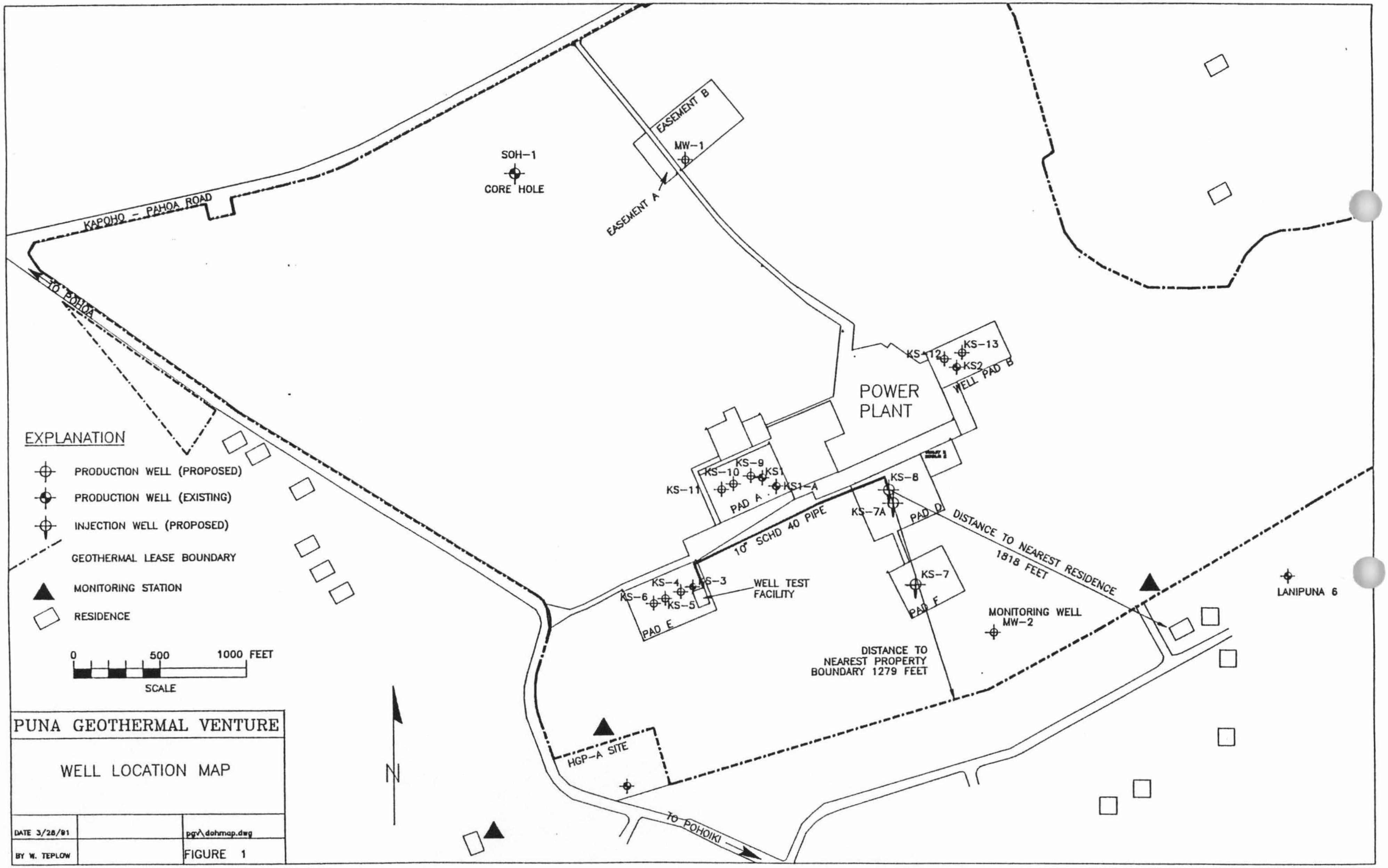
4. Pump water into drill pipe and casing to establish standard conditions.

5. Start 10 ppg fluid down the casing. Rate determined in Step 2. Expected to be a nominal rate at initiation. (3 bpm)

6. Start 22 ppg fluid down the drill pipe. Rate to be maximum within pressure rating and equipment limits. Expected to be greater than 12 bpm. Drill pipe should go on vacuum. Continue to pump at the max rate.

7. Anticipate reduction in casing pressure toward zero. When casing pressure is less than 50 psi begin pumping LCM loaded fluid down the casing.

8. Reduce rate of pumping on the drill pipe to a nominal 4 bpm to maintain the fluid column between 3450' and the shoe at 2100'. Timing will be according to the



KAPOHO - PAHOA ROAD
TO PAHOA
SOH-1
CORE HOLE
EASEMENT B
MW-1
EASEMENT A
POWER PLANT
KS-12
KS-13
KS2
WELL PAD B
KS-9
KS-10
KS1
KS-11
KS1-A
PAD A
KS-8
KS-7A
PAD D
10" SCHD 40 PIPE
DISTANCE TO NEAREST RESIDENCE 1818 FEET
KS-4
KS-3
KS-6
KS-5
PAD E
WELL TEST FACILITY
KS-7
PAD F
MONITORING WELL MW-2
LANIPUNA 6
DISTANCE TO NEAREST PROPERTY BOUNDARY 1279 FEET
HGP-A SITE
TO POHOIKI
N
EXPLANATION
PRODUCTION WELL (PROPOSED)
PRODUCTION WELL (EXISTING)
INJECTION WELL (PROPOSED)
GEOTHERMAL LEASE BOUNDARY
MONITORING STATION
RESIDENCE
0 500 1000 FEET
SCALE
PUNA GEOTHERMAL VENTURE
WELL LOCATION MAP
DATE 3/28/91
pgv\dohmap.dwg
BY W. TEPLOW
FIGURE 1

schedule of Step 2.

9. If the cross flow is stopped as evidenced by the reduced casing side pressure, then initiate pumping heavy cement at 5 bpm down the drill pipe.

10. Pump 45 bbl of 15.2 ppg cement.

11. Displace to bit with 22 ppg mud.

12. Strip out two stands of drill pipe.

13. Monitor the casing pressure. Pump additional 50 bbls of 22 ppg mud on top of cement should pressure start to rise. If the casing pressure is then controlled pump 50 bbls of 15.2 cement and strip out two more stands.

14. Verify that the well is dead and that cross flow is shut off by surface pressures and running a temperature - pressure survey to the bottom of the drill pipe.

15. Strip to shoe and squeeze 100 bbls of cement at the shoe.

16. Evaluate situation. Wait on cement 8 hrs.

17. Pull out of the hole and secure the equipment. Continue to monitor flows and temperatures.

2.6 Well Completion Program

Once the bottomhole entry and leakage at the shoe are plugged off and pressure is controlled with fluid in the well, the plug at the shoe will be drilled out. The 9-5/8" casing will be run to the top of the lower plug. The options of running the casing as a single string or as a cemented liner and tie-back will be decided upon according the competence of the well bore. Lead and tail cement will be designed to accommodate well bore frac gradient.

Lower plug will be drilled out with mud weight based on reservoir pressure calculated from the boiling point for depth curve. Drill pipe will be tripped out of the hole using the snubbing unit if necessary.

3 ASSESSMENT OF RESERVOIR CONDITIONS CAUSING THE EVENT

3.1 Geologic Setting

KS-8 is located at the foot of Puu Honuaula, a cinder cone dated at 500 to 750 yrs bp and is approximately 450 ft. southeast of the 1955 eruption vent fissure. The well penetrated 3478 ft. T.V.D. (true vertical depth) of basaltic lava flows and dikes belonging to the Puna Volcanic Series. The upper 3064 ft. T.V.D. of the formation is composed of a succession of subaerial lavas flows, flow breccias and cinder scoria cut by very rare dike rocks. This section is extremely permeable, especially above 2,000 ft., and is host to ground water circulation. Ground water within the project area is anomalously warm and has an anomalously high total dissolved solids content indicating natural leakage of fluid from the underlying geothermal reservoir.

Between 3065 ft. and total depth, a sequence of hyaloclastites intercalated with more common dike rocks and minor basalt flows was encountered. The hyaloclatites are layers of granular, glassy fragments representing basaltic ash flows and consolidated black sand deposits which demarcate a transitional zone between subaerial and submarine lava flows.

There is little evidence for mineralized, geothermal fluid-bearing fractures above 2,800 ft. T.V.D. in KS-8. Hydrothermal alteration was manifested by trace amounts of disseminated pyrite and minor smectite alteration of basaltic glass. Beginning at 2820 ft., trace amounts of subhedral to euhedral anhydrite, indicative of fluid bearing open vugs and fractures, were observed. The first appearance of drusy anhydrite corresponds to a sharp temperature increase observed on wireline temperature logs which were run to a depth of 3325 ft.

Between 3070 and 3180 ft. M.D. (measured depth) a fluid bearing zone was penetrated. This zone was characterized by the appearance of trace amounts of subhedral to euhedral anhydrite and quartz and significant smectite replacement of the hyaloclastite material. No drilling breaks were observed while drilling this interval, but temperature increases recorded during surveys and an intermittent weak flow of fluids observed during surveys beginning at 3142 ft. indicated the presence of geothermal fluids within the 3070 to 3180 ft interval. Only rare to trace occurrences of drusy anhydrite and quartz were observed in the cuttings between 3180 and 3488 ft. M.D. The last sample collected, representing the 3430 to 3440 ft. interval contained trace amounts of euhedral quartz as had been observed from 3070 feet.

3.2 Reservoir Pressure and Temperature Conditions

A pressure and temperature survey was run through the drill-pipe to 3400 feet MD on June 21 while water was being injected into the 13-3/8" casing at a rate of 3 bbl/min. The results are shown in Figure 5. The temperature profile clearly indicates an internal flow is present in the open hole section. A water-steam mixture at a temperature of 633 deg.F and pressure of about 1950 psig is entering the bottom of the well, flowing up the 12-1/4" open hole around the drill pipe, and exiting the wellbore at the shoe of the casing at 2128 feet.

The unexpectedly high reservoir temperature and pressure at this depth (for comparison the temperature in KS-3 at this depth is only 430 deg.F), explains why the well kick developed very rapidly into a high velocity fluid impact at the wellhead. Once initiated the very rapid expansion of the high temperature, high pressure steam moving up the wellbore quickly accelerated the mud column above it.

The kick took place when drilling with 10.5 lb/gal mud at a depth of 3488 feet MD (3478' TVD). This mud weight corresponds to a bottom-hole pressure of 1900 psig. Therefore, the reservoir pressure must exceed this pressure since the bottom-hole pressure must exceed the pressure exerted by the mud column in order for the kick to occur. Another estimate of the reservoir pressure can be obtained from the pressure and temperature survey. The pressure at the maximum survey depth of 3400 feet MD (3390 feet TVD) was 1939 psig. The pressure gradient over the bottom few hundred feet of the survey was about 0.28 psi/ft. Therefore the extrapolated pressure at the bottom of the well is 1963 psig.

The measured pressure at 3400 feet is within 10 psi of the steam saturation pressure for 633 deg.F. This very close agreement is within the accuracy of the instruments and indicates the gas partial pressure and hence gas content of the fluid is low.

It is likely that some boiling is occurring at the inflow zone. Boiling reduces the fluid temperature and pressure and therefore the static (i.e. non-flowing) reservoir temperature is probably higher than the 633 deg.F and 1963 psig given by the survey.

The static reservoir conditions cannot be derived directly from the data available. However, the inflow zone appears to be very prolific and therefore the boiling is likely to be minor. If it is assumed that the static temperature is 640 Degrees Fahrenheit then the static pressure would be around 2100 psig. It is interesting to note that the local ground water system exerts a hydrostatic pressure of about 1250 psig at the bottom-hole depth of KS-8. Therefore, the artesian pressure of the producing zone is about 850 psig above normal hydrostatic.

The shallow high pressure and temperature reservoir conditions appear to be very localized. Of the deep wells drilled in area, only KS-7 and KS-8 have encountered these conditions. These two wells are surrounded by other deep wells at distances of 1000 - 2500 feet that encontered similar temperatures only at depths below 6000 feet. None of the other wells exhibited the high artesian pressures of KS-7 or KS-8.

3.3 Flowrate During the Event

The well was discharged through a 4" choke for 31 hours. The flowrate could not be measured directly during this period. A rough estimate derived on the basis of the measured drill-pipe pressure indicates the total flowrate was on the order of 300,000 lb/hr. Over 70 percent of this was probably steam, the remainder being water.

4 MODES OF EQUIPMENT MALFUNCTION AND FAILURE DURING THE EVENT

4.1 Blow Out Preventer Stack (Figure 2)

The probable cause of failure was insufficient flow capacity to relieve pressure kick. The insufficient relief flow area caused the annular preventer element to fail. The failed preventer element choked the flow path between the Hydril and the flowline outlet from the rotating head. This resulted in a second rupture that damaged the mud line and the flow line. This also caused the rig floor to be displaced. This prevented the driller from staying on the brake resulting in the kelly dropping down. The position of the kelly interfered in the complete closure of the upper pipe ram. The leakage around the upper pipe ram totally engulfed the rig floor in steam.

The annular preventer had been activated and the driller was attempting to pull the pipe into the pipe ram area for a closure around the drill pipe. The explosive release of gas and/or steam from the annular preventer and then the rotating head and spacer prevented normal opening of the panic line and the closure of the rams. Under normal circumstances this would be followed by diverting through the choke and sequential closure of the well.

The complete lack of visibility on the rig floor and the displacement of the floor plates and other parts of the rig necessitated waiting until daylight before proceeding. The rupture of the annular preventer and the rotating head and spacer damaged the mud line, flow line, and pneumatic control lines under the rig floor. When daylight permitted activity corrections to the situation were begun.

4.2 Drill Rig Components

As noted when the release of energy took place there was damage to the flow line, the mud line, pneumatic lines to the drawworks, and the floor plate structure of the rig. The other components of the well control equipment and choke system were intact.

Due to the steam on the floor coming through the pipe ram closed around the kelly the operation of the drawworks and pumps had to be rigged from off the floor.

4.3 Indicated Equipment Modifications

There are three areas of equipment modification that would mitigate the problems that existed with the events of 6/12/91. The following revisions are being considered. More examination and analysis may modify the approach but the functional need will still exist.

With the high temperatures of this resource there is a need for a larger flow relief from the stack. This will prevent damage to the well control equipment, allowing the flow to be constrained more rapidly. The revised BOPE stack is shown in Figure 4. The 13-3/8 relief line gives the needed flow capacity. This approach has been used in high pressure gas well applications. The relief line has a burst plate to automatically divert the flow away from the floor so that the necessary actions can be taken. In addition to the 13 -3/8" diverter line the new stack design will include one more ram set in the control stack.

The second area of change being considered is to increase the normal choke assembly flow capacity. The reasons for this are somewhat similar to the reasons for a change in the preventer stack.

The third area of change is the remote operation of the choke valves themselves. Currently the HCR valve is remote but the variable choke settings cannot be done remotely. Also the choke manifold will be place further from the rig floor.

An area under consideration is a secondary station to control pump flow and some of the drawworks operations. This area is only under consideration at this time.

Further investigation may reveal additional areas to be modified.

5 WELL CONTROL SYSTEM MODIFICATIONS TO PREVENT RECURRENCE OF THE EVENT

5.1 Blow Out Preventer Stack

The BOPE stack shown in Figure 4 is designed to cover the increased flow requirements. The system actuation needs for the cummulator system will need to be upgraded to match the stack changes as well.

5.2 Well Control System

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The well control approach will be altered to circulating bottoms up through the choke and back into the pits when well temperatures of 400 F are encountered. It may be necessary to circulate bottoms up for connections as well but that change will need to be determined through testing. With the resource fluids on or near the boiling curve controlled bottoms up circulation will need to be used near the resource. Setting depths for the production string (as well as others) will need to be based on temperature and any indication of tendency to flow.

5.3 Casing Program

The casing program for a production well will call for a change in the setting criteria. The pipe sizes will not need to be changed at this time. The production string criteria will need to be based on temperature and leakage. Absence of mineralization will not preclude the setting of the casing. Temperature and leakage are clear indications of being in the reservoir cap.

5.4 Monitoring Drilling Functions

A Visulogger style drillers panel will be installed to give the driller quicker information on parameter variation. The change in equipment will also make possible improved alarm setting and trend analysis of the drilling parameters.

Improved downhole information on a more timely basis should improve the knowledge of downhole pressure and temperature. Electronic heat shielded memory tools are being investigated to give downhole temperature information. These tools can be run in logging mode and down loaded into computers for more timely temperature profile data.

5.5 Monitoring Geotechnical Data

The use of the Visulogger style sensor presentation will also carry over to the logging of the geological information. The integration of the data base before the fact may indicate early information on slight variations.

6 DRILLING PROCEDURE MODIFICATIONS TO PREVENT RECURRENCE OF THE EVENT

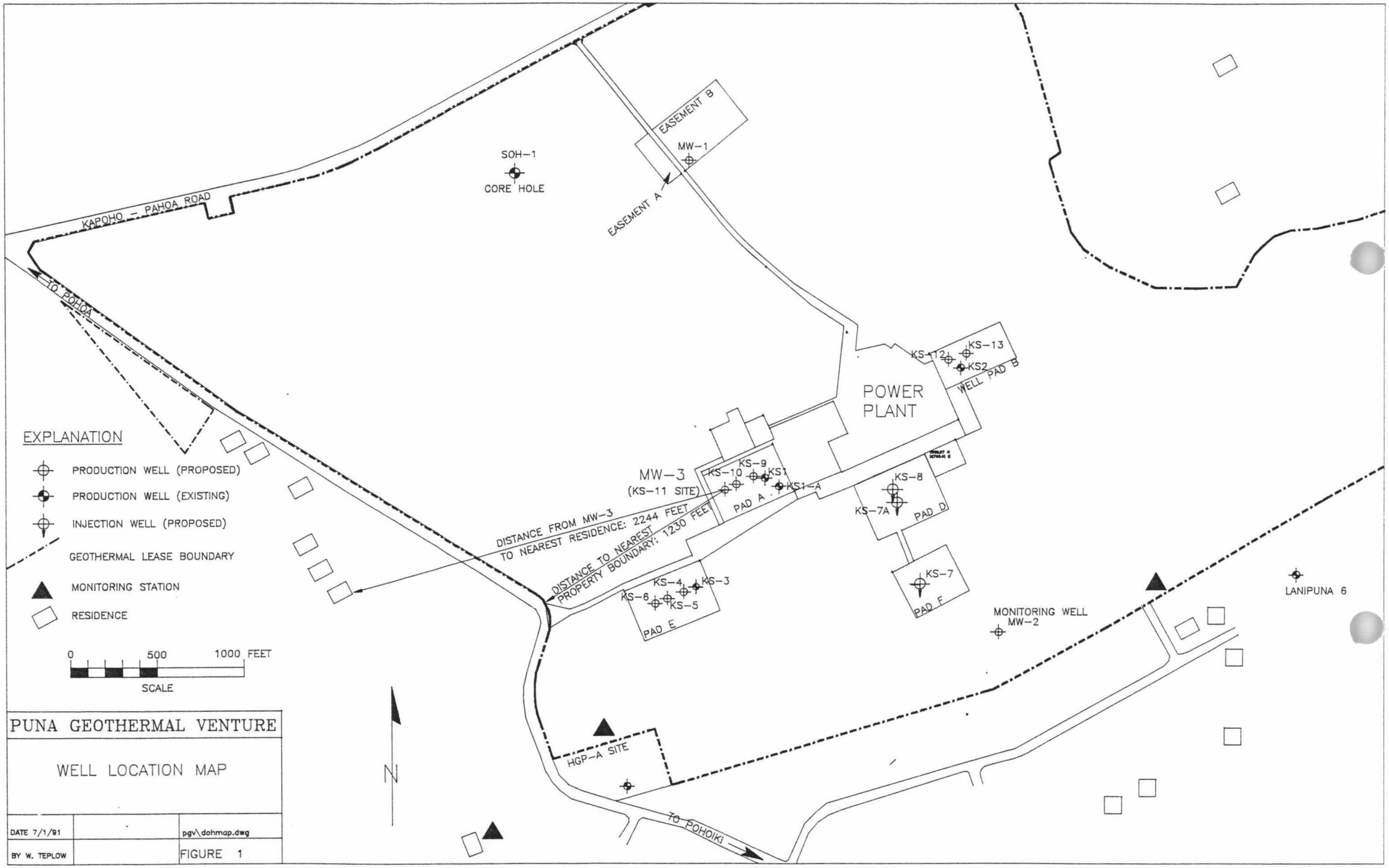
6.1 Drilling Fluid Program

The drilling fluid composition will not be substantially changed. The viscosifier and water loss materials are doing there job at the present time.

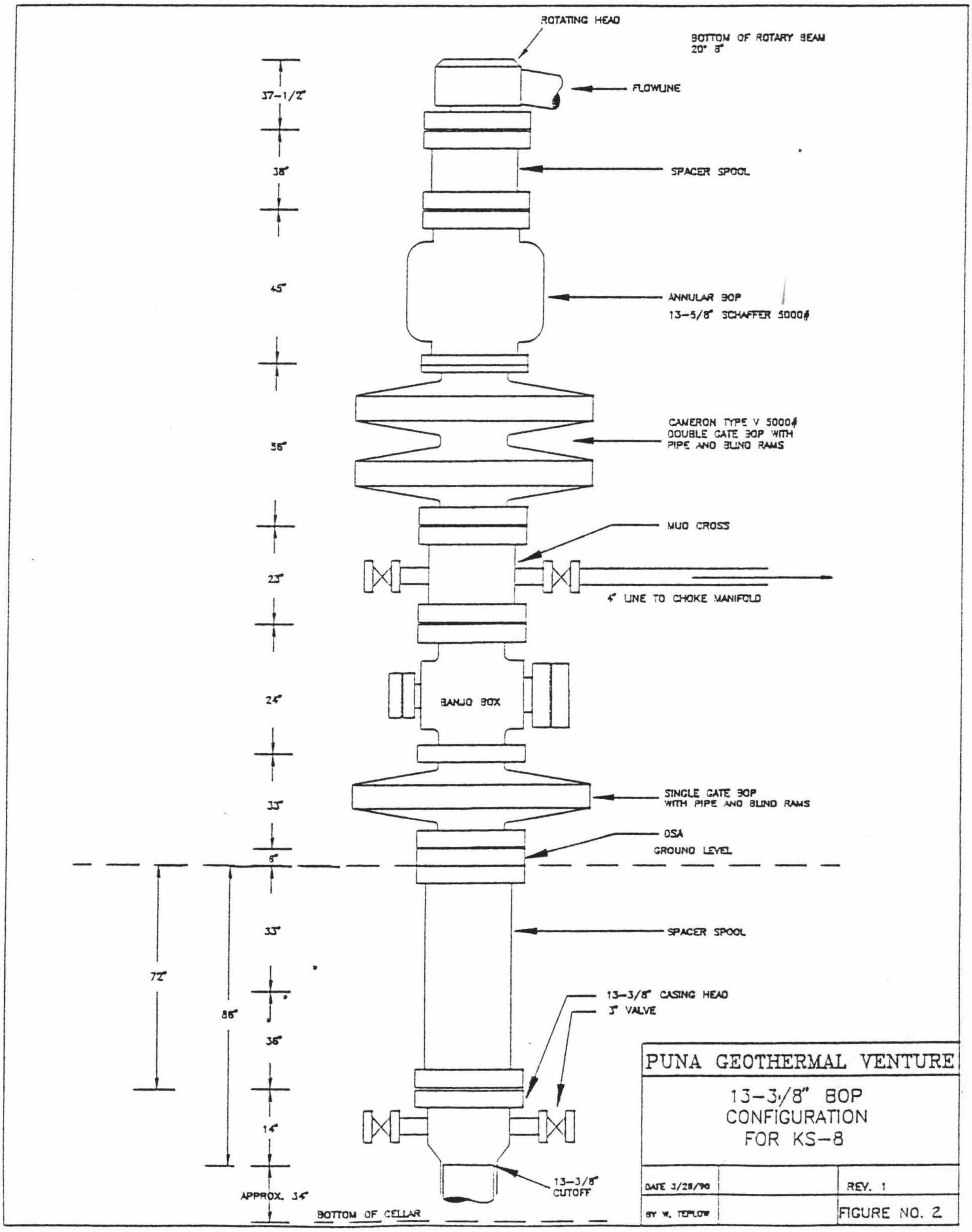
The major change to the drilling fluids program is the mud weight will have to be dictated by the boiling point temperature- pressure relationship. Anticipation of weight changes will need to take into account the bottom hole temperature in the determination of the required mud density to control the formation fluids.

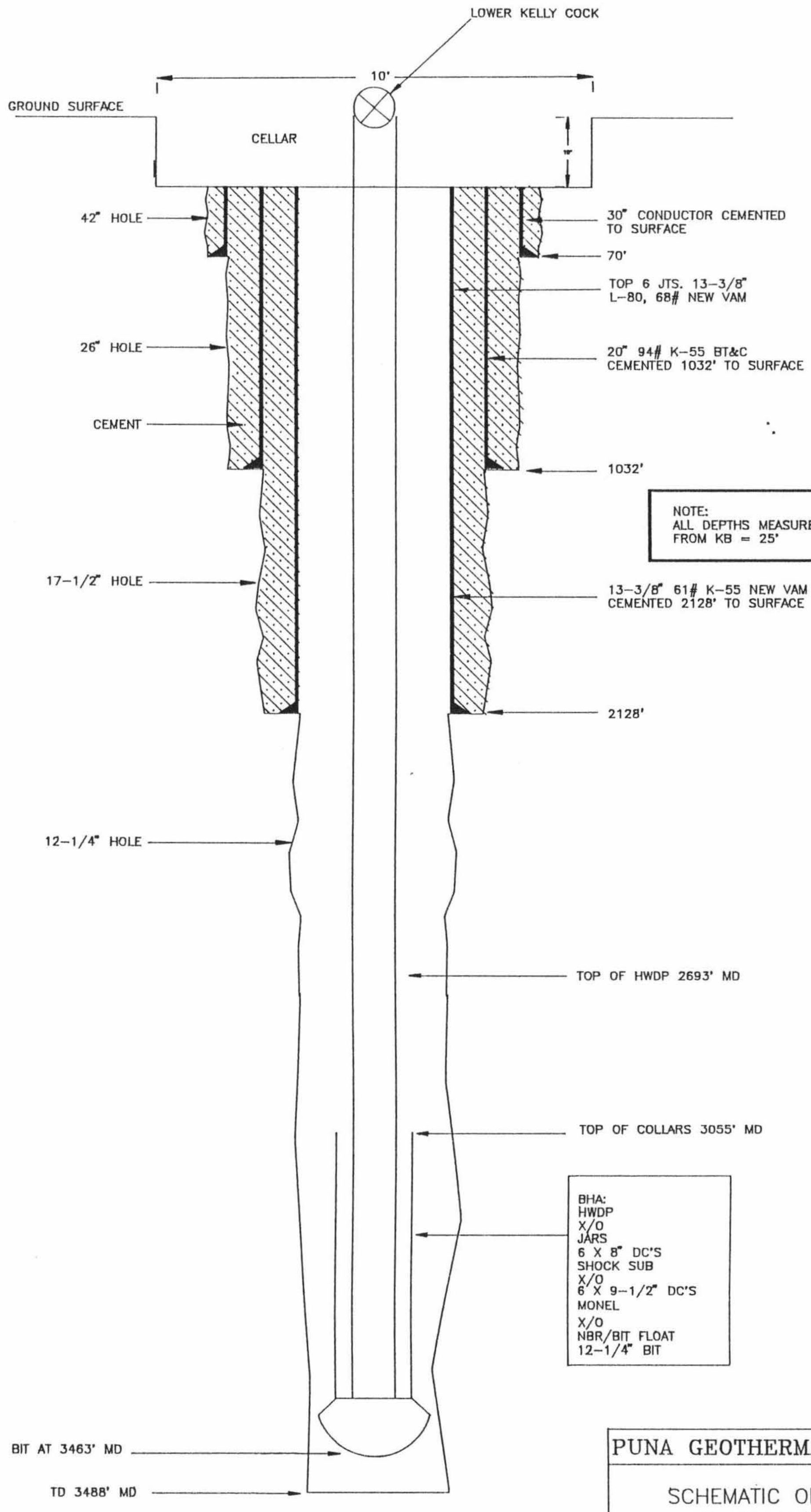
6.2 Casing Procedures

The casing program will now call for a bottom hole cement plug, flow monitoring and temperature logging to clarify the situation downhole before the production casing is run.



KAPOHO – PAHOA ROAD
TO POHOA
SOH–1
CORE HOLE
EASEMENT B
MW–1
EASEMENT A
POWER PLANT
KS–12
KS–13
KS2
WELL PAD B
MW–3
(KS–11 SITE)
KS–10
KS–9
KS1
KS1–A
PAD A
KS–8
KS–7A
PAD D
KS–7
PAD F
KS–4
KS–3
KS–6
KS–5
PAD E
DISTANCE FROM MW–3 TO NEAREST RESIDENCE: 2244 FEET
DISTANCE TO NEAREST PROPERTY BOUNDARY: 1230 FEET
MONITORING WELL MW–2
LANIPUNA 6
HGP–A SITE
TO POHOIKI
N
EXPLANATION
PRODUCTION WELL (PROPOSED)
PRODUCTION WELL (EXISTING)
INJECTION WELL (PROPOSED)
GEOTHERMAL LEASE BOUNDARY
MONITORING STATION
RESIDENCE
0
500
1000 FEET
SCALE
PUNA GEOTHERMAL VENTURE
WELL LOCATION MAP
DATE 7/1/91
pgv\dohmap.dwg
BY W. TEPLOW
FIGURE 1

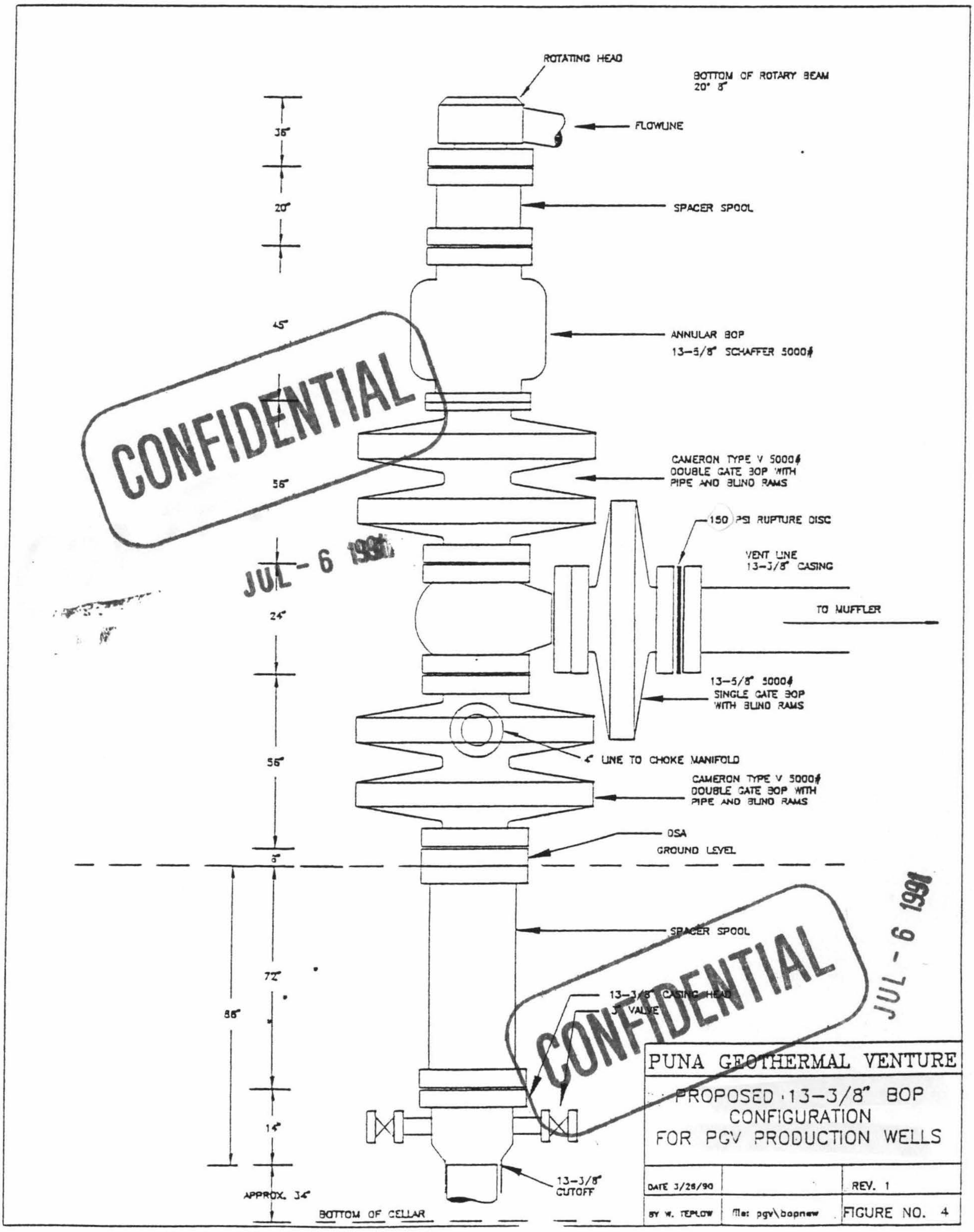

ROTATING HEAD
BOTTOM OF ROTARY BEAM 20' 8"
FLOWLINE
37-1/2"
38"
SPACER SPOOL
45"
ANNULAR BOP
13-5/8" SCHAFFER 5000#
CAMERON TYPE V 5000# DOUBLE GATE BOP WITH PIPE AND BLIND RAMS
36"
MUD CROSS
23"
4" LINE TO CHOKE MANIFOLD
24"
BANJO BOX
SINGLE GATE BOP WITH PIPE AND BLIND RAMS
33"
DSA
GROUND LEVEL
8"
33"
SPACER SPOOL
72"
86"
13-3/8" CASING HEAD
3" VALVE
36"
14"
13-3/8" CUTOFF
APPROX. 34"
BOTTOM OF CELLAR
PUNA GEOTHERMAL VENTURE
13-3/8" BOP CONFIGURATION FOR KS-8
DATE 3/28/90
BY W. TEPLOW
REV. 1
FIGURE NO. 2



PUNA GEOTHERMAL VENTURE

SCHEMATIC OF KS-8
AS OF 6/23/91

DATE 6/23/91		REV. 1
BY W. TEPLOW	FILE: PGV\KS3COMPL.DWG	FIGURE NO. 3



ROTATING HEAD
BOTTOM OF ROTARY BEAM
20' 8"
FLOWLINE
38"
20"
SPACER SPOOL
45"
ANNULAR BOP
13-5/8" SCHAFFER 5000#
CAMERON TYPE V 5000#
DOUBLE GATE BOP WITH
PIPE AND BLIND RAMS
56"
150 PSI RUPTURE DISC
VENT LINE
13-3/8" CASING
TO MUFFLER
24"
13-5/8" 5000#
SINGLE GATE BOP
WITH BLIND RAMS
4" LINE TO CHOKE MANIFOLD
56"
CAMERON TYPE V 5000#
DOUBLE GATE BOP WITH
PIPE AND BLIND RAMS
DSA
GROUND LEVEL
8"
SPACER SPOOL
72"
86"
13-3/8" CASING HEAD
3" VALVE
14"
13-3/8"
CUTOFF
APPROX. 34"
BOTTOM OF CELLAR
PUNA GEOTHERMAL VENTURE
PROPOSED 13-3/8" BOP
CONFIGURATION
FOR PGV PRODUCTION WELLS
DATE 3/26/90
REV. 1
BY W. TEPLOW
file: pgv\bopnew
FIGURE NO. 4
CONFIDENTIAL
JUL - 6 1991
CONFIDENTIAL
JUL - 6 1991

PUNA GEOTHERMAL VENTURE
KS-3 STATIC TEMPERATURE
KS-8 STATIC TEMPERATURE AND PRESSURE PROFILES

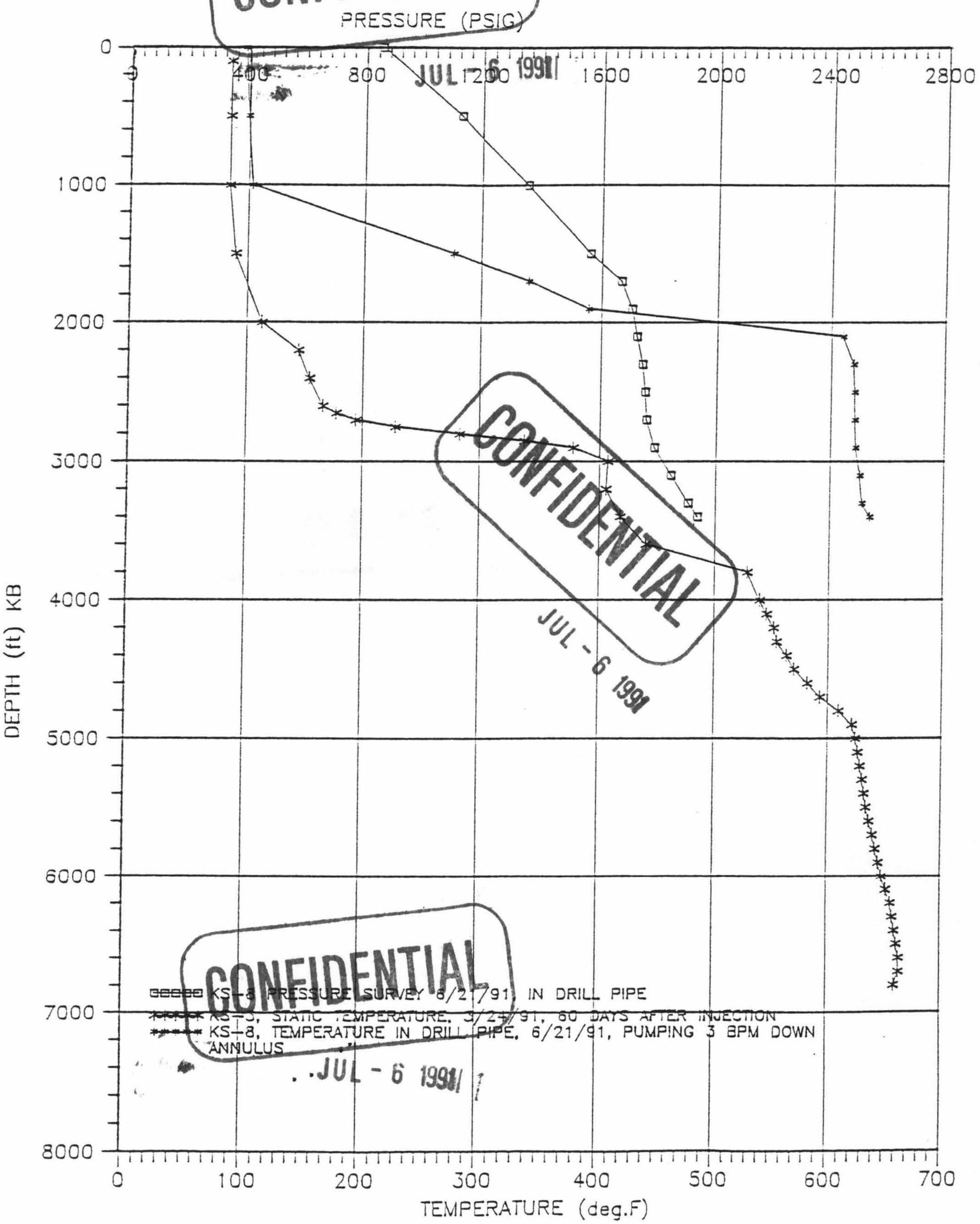


FIGURE 5